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ESOX LUCIUS (ESOCIDAE) AND *STIZOSTEDION VITREUM* (PERCIDAE) IN THE GREEN RIVER BASIN, COLORADO AND UTAH

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ABSTRACT.—Northern pike, *Esox lucius*, stocked in the Yampa River in 1977, invaded the mainstream Green River by 1981 and subsequently increased in range and abundance. The speed of this invasion is indicated by two recaptured pike that moved 78 and 110 km, respectively, downstream in about one year. Pike stomachs (n = 123) were usually empty (54.5%), but some contained fish (43%) and nonfish items (2.4%). Red shiner, *Notropis lutrensis*, and fathead minnow, *Pimephales promelas*, predominated among the 12 fish species eaten. Walleye, *Stizostedion vitreum*, presumably introduced to the Green River drainage in the 1960s, was widely distributed but low in abundance. Most of 61 adult walleye stomachs contained food (60.7%); of 6 fish species eaten, channel catfish, *Ictalurus punctatus*, and fathead minnow were most frequently consumed. Northern pike and walleye were captured in habitats occupied by endangered Colorado River fishes, particularly Colorado squawfish, *Ptychocheilus lucius*. Predation on endangered fishes was not detected, but northern pike and walleye consumed at least three other native fishes. The northern pike may pose a threat to endangered fishes due to its population expansion, piscivory, and resource sharing. Diets of northern pike and walleye species should be further evaluated if their abundance increases.

Northern pike were introduced into Elkhead Reservoir, an impoundment on the Yampa River drainage, in 1977 (P. J. Martinez, personal communication) and collected in the mainstream Yampa River as early as 1979 (E. J. Wick, personal communication). Their numbers increased in the upper Yampa River in the early 1980s (Wick et al. 1985), and a downstream movement into the Green River was subsequently documented in 1981 (Tyus et al. 1982, Green River fishery investigations). Northern pike reproduction has been reported in the upper Yampa River drainage, where it has access to the mainstream river (T. P. Nesler, personal communication).

Walleye presumably accessed the mainstream Green River by moving downstream from various tributaries. The fish was first reported in Utah in 1951 (Sigler and Miller 1963), and reproducing populations of walleye were established by fish stockings in Duchesne River reservoirs (Fig. 1) in the 1960s and 1970s (G. M. Davis, personal communication).

The Green River basin of Colorado and Utah is an important recovery area for four rare and endangered Colorado River fishes (reviewed by Joseph et al. 1977, Carlson and Carlson 1982, U.S. Fish and Wildlife Service 1987). However, over 20 nonnative fishes have been introduced into the basin for sport, forage, food, or by accident (Tyus et al. 1982, Fishes of upper Colorado). Impacts of these introduced fishes on the native fauna are not well understood, but the presence of two large piscivores, northern pike, *Esox lucius*, and walleye, *Stizostedion vitreum*, in areas presently occupied by endangered fishes, is cause for concern. Control of nonnative fishes has been identified as a recovery measure under provisions of an interagency recovery program for endangered fish species in the upper Colorado River basin (U.S. Fish and Wildlife Service 1987). Fish introductions in other locations have eliminated or partially extirpated native fish faunas, and the instability of resultant communities has caused management problems (Moyle et al. 1986).

The purpose of this study was to determine diets of northern pike and walleye in the Green River, and to evaluate the degree of predation on native and endangered fishes. We also document the recent invasion of northern pike into the Green River basin, and the abundance and distribution of northern pike and walleye in the mainstream Green River. The results of this study are interpreted relative

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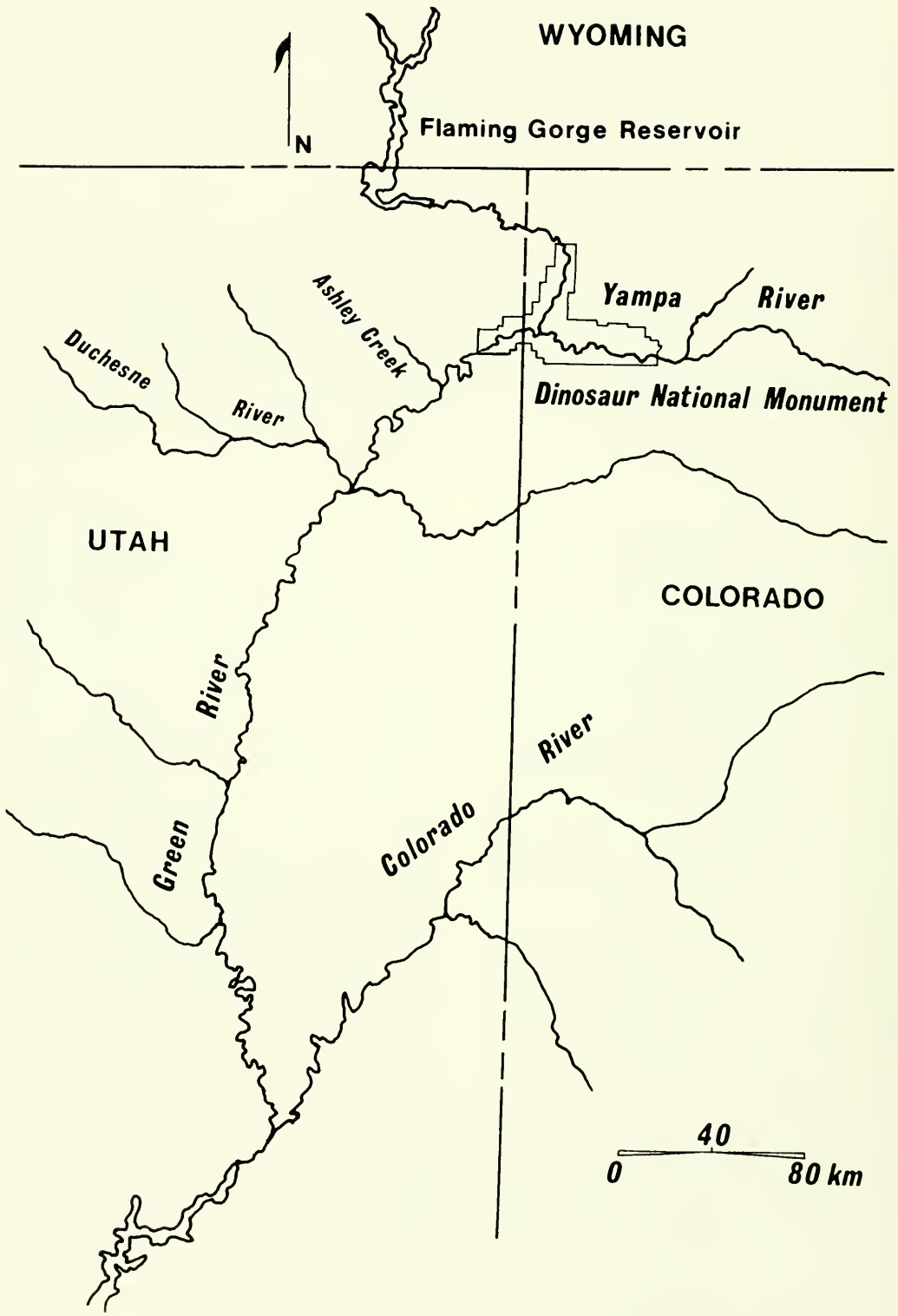

Fig. 1. Map of the study area.

to potential interactions of these species with sympatric endangered Colorado River fishes.

METHODS

Northern pike and walleye were primarily collected by electrofishing. Sampling was conducted from April to November 1979–1981 and from April to June 1984–1988 in 517 km of the mainstream Green River. The study area included the mainstream Green River from its confluence with the Yampa River in Dinosaur National Monument to a point 35 km above the confluence of the Green and Colorado rivers (Fig. 1). The lower 73 km of the Yampa River was also sampled 1984–1989. In 1989, spring sampling was conducted in the lower 73 km of the Yampa River and in the Green River in a 208-km reach below its confluence with the Yampa River (Fig. 1).

In 1979–1981, fishes were sampled with a variety of gear, including electrofishing, seines, trammel nets, and wire traps, depending on gear suitability; sampling was conducted during prerunoff, runoff, and postrunoff conditions. In 1984–1988, sampling included only alongshore electrofishing in the prerunoff and early runoff period and involved continuous downstream coverage with a pulsed DC unit. Electrofishing collections in which all shoreline habitats were sampled were considered representative collections, and catches of fishes per hour (C/h) sampled were recorded. Some opportunistic spring electrofishing was also conducted in suspected northern pike and walleye habitats; however, no C/h data were reported for these samples.

All northern pike and walleye collected were measured for total length (TL). Location of capture was also noted. After 1983, all fish were sacrificed and stomach contents identified to the lowest possible taxon with the aid of a 25X binocular dissecting scope. The date, location, and water conditions at the point of capture of all females with ripe eggs and fully developed ovaries were recorded. We also obtained 49 northern pike and 11 walleye stomachs from other workers and identified their contents.

RESULTS

Abundance and Distribution

Eighty-four northern pike were collected from 1979 to 1989, including 33 females in breeding condition (mature ovaries with ripe eggs). Ripe females were captured in April–June in the mainstream Green River at water temperatures of 10–19 C. All pike were considered adults or large juveniles based on size (average = 619 mm TL, range 321–1,045 mm; Carlander 1969). Average catch of northern pike increased 0.05–0.14 fish per hour from 1984 to 1988 (Table 1). Seventy-eight percent (n = 59) of the pike were collected in the upper Green River in 1984–1988, but many of these (43%) were taken in shallow, low-velocity, shoreline habitats at the mouth of Ashley Creek. Northern pike were spotty in distribution but sometimes abundant in semiimpounded habitats. Their captures were often associated with prominent aquatic and bank vegetation.

TABLE 1. Catches of adult northern pike (*Esox lucius*) and walleye (*Stizostedion vitreum*) per hour of electrofishing (C/h), in the Green River, Utah, April–June 1984–1988 (n = number of fish). Upper Green River = km 337.8–552, lower = km 35–337.7.

River location	Hours fished	Northern pike		Walleye	
		n	C/h	n	C/h
		1984			
Upper	101.2	20	.20	15	.15
Lower	32.3	0	—	0	—
		1985			
Upper	886.9	4	.005	8	.01
Lower	28.9	0	—	0	—
		1986			
Upper	753.2	5	.01	17	.02
Lower	35.9	0	—	0	—
		1987			
Upper	760.1	16	.02	8	.01
Lower	37.2	1	.03	1	.03
		1988			
Upper	441.5	9	.02	0	—
Lower	43.0	3	.07	1	.02

We captured two tagged northern pike in this study. These adult fish (594 and 820 mm TL) were tagged by Colorado Division of Wildlife personnel in the Yampa River in 1982 and 1988 (E. J. Wick and T. P. Nesler, personal communication). One fish had moved about 110 km between 15 April 1982 and 10 May 1983 when we recaptured it in the Yampa River at km 18.4. The other pike had

Table 2. Contents of 123 northern pike (*Esox lucius*) stomachs taken in the Green River basin, Utah and Colorado, 1984–1989.

Species	Status[a]	Number of prey	Frequency (%)
		Fishes	
unidentified fish	—	40	10.6
Notropis lutrensis	I	24	7.3
Pimephales promelas	I	15	4.1
Catostomus latipinnis	N	6	4.1
Rhinichthys osculus	N	7	3.3
unidentified *Notropis* spp.	I	6	2.4
Gila atraria	I	3	2.4
Catostomus discobolus	N	2	1.6
Ictalurus punctatus	I	2	1.6
Cyprinus carpio	I	3	0.8
Notropis stramineus	I	2	0.8
unidentified Cyprinidae	I	1	0.8
unidentified *Gila* spp.[b]	—	1	0.8
Oncorhynchus mykiss	I	1	0.8
Oncorhynchus clarki	I	1	0.8
Richardsonius balteatus	I	1	0.8
		Other	
empty	—	—	54.5
Rana pipiens	N	1	0.8
Lampropeltis spp.	N	1	0.8
detritus	—	—	0.8

[a]N = native species, I = introduced species.
[b]suspected *Gila robusta*

traveled 78 km from 16 June 1988 to 23 May 1989, when it was recaptured at km 4.8. Growth of these fish averaged only 10 mm TL.

Walleye were also captured in the upper Green River (90%, n = 50) and averaged 511 mm TL (range 395–686 mm). These fish were presumed juveniles and adults, based on size (Carlander 1969). More widely dispersed than pike, walleye were usually captured in a variety of slow shoreline runs, usually associated with emergent or bank vegetation. One ripe female walleye (577 mm TL) was captured in the upper Green River on 15 May 1984 at a water temperature of 13 C. We captured one tagged walleye at the mouth of the Duchesne River on 21 May 1984. This fish was tagged by BIO/WEST Incorporated on 13 April 1979 at a point about 37 km upstream in the Green River (L. Crist, personal communication). This fish grew about 62 mm TL in five years.

Foods

Northern pike stomachs (n = 123) were usually empty (54.5%), but of the remainder, 97.6% contained fishes (Table 2). Red shiner, *Notropis lutrensis*, and fathead minnow, *Pimephales promelas*, were most frequently consumed of nine nonnative fishes. Flannelmouth sucker, *Catostomus latipinnis;* bluehead sucker, *C. discobolus;* and speckled dace, *Rhinichthys osculus*, were the native fishes consumed. Other prey items included a leopard frog, *Rana pipiens*, a king snake, *Lampropeltis* spp., and detritus. Thirteen stomachs (10.6%) contained fish remains that could not be identified.

Walleye in the Green River primarily consumed fishes, including 5 nonnative and 1 native species (Table 3). Of 61 stomachs examined, 24 (39.3%) were empty and 10 (16.4%) contained unidentifiable fish remains. Channel catfish, *Ictalurus punctatus*, and fathead minnow were the most frequently consumed nonnative fishes, and flannelmouth sucker was the only native fish consumed. Vascular plant material was found in one walleye stomach.

Discussion

Northern pike, introduced in the Yampa River drainage in 1977, was presumed absent in Green River until first reported in 1981 (Tyus et al. 1982, Fishes of upper Colorado). We captured the fish only in the upper Green River (km 337.8–552) from 1981 to 1986. Pike invaded the midsection (km 192–337.7) by

TABLE 3. Contents of 61 walleye (*Stizostedion vitreum*) stomachs taken in the Green River basin, Utah and Colorado, 1984–1989.

Species	Status[a]	Number of prey	Frequency (%)
		FISHES	
unidentified fish	—	38	16.4
Ictalurus punctatus	I	37	16.4
Pimephales promelas	I	35	9.8
Cyprinus carpio	I	4	6.6
Lepomis cyanellus	I	4	3.3
Catostomus latipinnis	N	1	1.6
unidentified Cyprinidae	I	2	1.6
Ictalurus melas	I	1	1.6
		OTHER	
empty	—	—	39.3
fish eggs	—	—	1.6
vascular plant material	—	—	1.6

[a]N = native species, I = introduced species.

1987, and it was first captured below Green River, Utah (km 192), in 1988. This invasion and downstream movement is supported by both the absence of the fish in the Green River in the early 1970s (Holden and Stalnaker 1975) and a first report of pike in the lower Green in 1988 (M. Moretti, personal communication). Although movements of northern pike in large rivers remain poorly documented, some studies in lakes and small streams have shown that the fish can display high mobility (Miller 1948, Ross and Winter 1981) but may move only short distances at a time (Cook and Bergersen 1988). Our recapture of two northern pike indicated that the fish can move long distances (> 75 km/year) in the Yampa River. Long-distance upstream and downstream movement of radiotagged northern pike has also been reported by T. P. Nesler (personal communication).

The majority of fishes consumed by northern pike in this study were soft-rayed forms (Table 2), as previously noted by others (Beyerle and Williams 1968, Weithman and Anderson 1977, Wolfert and Miller 1978). Channel catfish, the only spiny-rayed fish consumed, was found in two stomachs. We could not positively identify roundtail chub, *Gila robusta*, in northern pike stomachs taken from the Yampa River, but presumably one *Gila* spp. was a roundtail chub. T. P. Nesler (personal communication) reported that roundtail chub were present in northern pike stomachs he examined from the Yampa River. Most of the pike we examined were from the Green River where roundtail chub are rare (Tyus et al. 1982, Fishes of upper Colorado), and this may have resulted in the relative absence of roundtail chub as prey in pike stomachs we examined.

Northern pike may spawn in the mainstream Green River, but if so, recruitment is low. We did not capture small northern pike (< 321 mm TL) in this study, and, to our knowledge, pike reproduction has not been noted by others. However, one 115-mm-TL specimen was seined by HMT and others from a shoreline area of the Green River in Dinosaur National Monument on 8 July 1988. It is not known whether this fish hatched in the Green River or was transported there from another location. Also, we captured several ripe female pike, and it is possible that some of these fish spawned in the Green River. Most ripe female pike (76%) had empty stomachs, suggesting a reduction in feeding activity with increasing water temperatures and ripening ovaries (Frost 1954, Lawler 1965).

Walleye were rare in the Green River, and their long period of residency suggests that their numbers will probably not increase. Walleye were easily captured by electrofishing, and very few fish that we sighted escaped capture. However, it was difficult to capture northern pike with electrofishing, and many fish escaped. A direct comparison of the relative abundance of walleye with that of northern pike could be somewhat misleading, and it is noted that walleye were more rare, and northern pike more abundant, than indicated by electrofishing catch rates. We captured

only one female walleye with developed ovaries, and that was in May at a water temperature of 13 C. Walleye in other locations usually spawn at cooler water temperatures (3.3–7.2 C, Sigler and Miller 1963; 5.6–11.1 C, Scott and Crossman 1973). No small walleye (< 395 mm TL) were captured in this study.

Young of the endangered humpback chub, *Gila cypha;* bonytail chub, *G. elegans;* razorback sucker, *Xyrauchen texanus;* and Colorado squawfish, *Ptychocheilus lucius*, may be potential prey for northern pike and walleye. None of these fishes were identified in stomachs of northern pike or walleye, but our ability to detect such predation was constrained by a small sample size of stomachs that contained food, rarity of endangered fishes, and inability to identify all of the fishes eaten.

Sympatry of adults of northern pike, walleye, and endangered fishes is a cause for concern, particularly if resource sharing occurs during periods of limited availability. We collected northern pike, walleye, and Colorado squawfish in similar shoreline habitats in the mainstream Green River; in addition, radiotagged northern pike and Colorado squawfish were syntopic in the Green and Yampa rivers (Valdez and Masslich 1989, Wick and Hawkins 1989). Northern pike were captured in shallow, flooded habitats also utilized by razorback sucker.

Stocking programs for northern pike and walleye have been discontinued by state agencies in Colorado and Utah (G. M. Davis and P. J. Martinez, personal communication), and the relative absence of small fish of both species suggests that reproduction in the mainstream Green River is low or nonexistent during most years. However, the continuing invasion of northern pike and walleye into the Green River from established, reproducing stocks should be monitored, and their interactions with endangered fishes further evaluated until it can be more clearly demonstrated that competition or predation on endangered fishes does not occur or pose a serious threat. The increasing abundance and spread of northern pike, the diversity of fishes consumed, and its syntopy with endangered fishes make this voracious piscivore a potential threat to endangered Colorado River fishes.

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